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ABSTRACT

Using schema theory as a contextual framework, three studies were conducted to examine the effects of two triggering mechanisms on transfer of learning across two noncontiguous passages: similar terminology for shared concepts and a brief review of the first passage read immediately before the second passage. The first two studies served to pilot the treatments and dependent measures used in the third and more complete experiment. Treatment materials for all three studies were two passages about computers. The first passage presented concepts about the parts of and their location within a computer and the second passage taught seven commands found in many programming languages. The dependent measures were similar for the studies, and included measures of comprehension of primary and secondary points content. Results produced conflicting evidence. The theoretical assumption that familiarity with technical terminology and a single organizing structure were prerequisites for comprehension and transfer were supported by the second study but not the third. Evidence from the second and third studies suggest that weak organizing schemata can actually impede positive transfer and rote learning. Twenty-six references are listed. (LMM)

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AVAILABILITY OF PRIOR KNOWLEDGE AND ITS EFFECT ON TRANSFER OF LEARNING

Paper presented at the AECT conference in January 1984 by

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Transfer of Learning in Education

Royer (1979) defines transfer of learning as a sequential process in which the learning of one passage facilitates the learning of a second conceptually similar passage. Transfer of learning, thus defined, has been demonstrated to occur when learners study two passages close in time and when the passages contain similar terminology for redundant concepts (Abramson, 1965; Scandura and Wells 1967; Merrill and Stolurow 1968; Royer and Cable 1975; Royer and Cable 1976; Ausubel 1978; Mayer 1977; Anderson, 1978; Adams & Collins, 1979; Mayer and Bromage 1980). However, there is little evidence to suggest whether transfer will occur in situations where learners do not read the second passage for several days or weeks, and/or where the passages do not contain the same terms for the concepts taught in both.

According to Mayer (1977) and Royer (1979), the process of facilitated transfer can only occur when the memory structures gained from the first passage are retrieved from long-term memory when the learner reads the second passage. While retrieval is almost certain for contiguous passages (two passages read close in time), empirical results say little about retrieval and its effect on transfer when there is a delay.

Many studies have measured retention of learning on delayed dependent measures and have found that students are able to recall

and/or recognize some but not all of the information they evidenced learning on an immediate dependent measure (Pickert and Anderson, 1977; Mayer and Bromage, 1980; Reder and Anderson, 1980). What is remembered seems to be a function of what is originally learned (i.e., facts versus meaningful concepts (Ausubel, 1978)), how it is learned (i.e., conceptual perspective (Pichert and Anderson, 1977)), and what cues are given at the time of recall (Pickert and Anderson, 1977). All three of these factors influencing delayed recall of memory structures have important implications for transfer of learning across two noncontiguous passages.

But, although research with delayed dependent measures shed some insights on how much previously learned information will be remembered when subjects are expressly asked to retrieve it, such research cannot lead to generalizations concerning how much a second passage will stimulate recall of a first passage read several days before. According to Mayer (1977), the availability of prior knowledge, as demonstrated on delayed retention tests, does not ensure that the prior knowledge will be retrieved from long-term memory when the second passage is encountered. There must be a triggering mechanism associated with the second passage which identifies what prior knowledge structures to retrieve (Bransford and Johnson, 1973; Royer, 1979; Rummelhart, 1980).

In my research during the past year I have examined the effects of two triggering mechanisms on tranfer of learning across two noncontiguous passages. They are similar terminology for shared concepts and a brief review of the first passage read immediately

before the second passage. Before summarizing that research, however, I will establish a theoretical basis for my inquiry in the context of schema theory.

Contribution of Schema Theory

Schema theory provides a comprehensive framework for studying the effects of similar terminology and reviews on transfer of learning across two passages. Current notions of schema theory incorporate concepts originating as far back as Bartlett (1932) and developed by numerous cognitive theorists (Neisser, 1976; Shank, 1976; Rummelhart & Norman, 1978; Rummelhart, 1980; Spiro, 1980).

According to Rummelhart (1980), a schema is a hierarchical structure interrelating information which constitutes a known concept such as an "object, situation, event, sequence of events, action and sequence of actions." The information in a schema includes data which specifies (1) the common attributes of instances of a concept, (2) variable attributes and the range of permissible variations, and (3) default values for missing attributes.

Any generic data, variable range or default assignment can be expressed in terms of another schema. In this way, schemata (plural of schema) embed one another. Rummelhart (1980) suggests that the "embedding characteristic of schemata" allows schemata to "represent knowledge at all levels--from ideologies and cultural truths to knowledge about what constitutes an appropriate sentence in our language, to knowledge about the meaning of a particular word."

In terms of schemata theory, memory consists primarily of interconnected and embedded schemata (diSibio, 1982). These schemata represent all one's generic knowledge about the world. A subset of them are retrieved, or activated during comprehension to allow a reader

to interpret incoming semantic information. When the network of retrieved schemata matches the sensory inputs at all levels of abstraction, comprehension easily follows (Bransford & Johnson, 1973; Shank, 1976; Rummelhart, 1980). When the schemata do not match a portion of the incoming data, either (1) other schemata are activated which match or (2) existing schemata are modified, else (3) comprehension breaks down. Without comprehension, meaningful verbal learning cannot occur (Ausubel, 1978), leaving rote learning or no learning as the only alternatives.

Retrieval of schemata from memory can occur somewhat automatically as incoming data seek to be matched or "instantiated." This describes a data driven, "bottom-up" mode of retrieval (Adams & Collins, 1979). Bottom-up retrieval starts at very concrete levels (word recognition) and works to higher levels (construction of meaning of sentences). An alternate mode, conceptually driven or "top-down" retrieval, activates schemata from an initially high, conceptual level to progressively lower levels in anticipation of incoming data (Adams & Collins, 1979; Runnelhart, 1980). Top-down retrieval searches for schemata which will allow anticipated semantic information to be understood upon arrival.

Both bottom-up and top-down processes contribute to transfer of learning of across passages they influence what schemata related to a first passage are retrieved from long-term memory to guide the learning of the second passage. More specifically, bottom-up processes can influence transfer by triggering the retrieval of available word-level schemata acquired from the first passage which match key words and phrases read in the second. From the word-level schemata, retrieval spreads upwards to more complex schemata. Consequently, when similar

terminology is used across two passages, bottom-up processes can more easily target the relevant schemata from the first passage (Kintsch et. al., 1975; Abramson, 1965).

Top-down processes facilitate transfer of learning when two passages are believed to conceptually overlap. That is, when learners recognize that the second passage overlaps with the first, top-down processes automatically retrieve available conceptual-level schemata related to a first passage. At which point, retrieval spreads down-ward to less complex schemata (Adams & Collins, 1979). Students have learned from past experience that two sequential passages (i.e., two chapters from a textbook) often conceptually overlap and that the first passage can provide a conceptual framework for understanding the second. Consequently, even when reading two contiguous passages from different sources (i.e., two journal articles), they will tend to retain many of the ideas from the first passage in working memory in anticipation of using them to better understand the second. However, as time passes between passages, other ideas replace those from the first passage and top-down processes may not be able to automatically ensure the availability of appropriate high-level schemata (Royer, 1979).

Summary of Research by Author

I have conducted three studies thus far in my research effort. The first two studies served to pilot the treatments and dependent measures used in the third and more complete experiment. Consequently, while I'll emphasize the last study of the series, the preliminary ones merit at least a brief review.

Treatment Materials

In all three studies, I employed treatment materials modified from materials developed by Mayer and Bromage (1980). They consisted of two passages about computers. The first passage presented concepts about the parts and locations within a computer. For each part, the passage presented the following information. 1) a simple representation of the part and its relationship to the other parts; 2) an analogy illustrating the form and function of the part in terms of a familiar object; and 3) a few elaborations and details associated with the part and its operation. Mayer and Bromage (1980) used the original form of these materials because they had found that students unfamiliar with computers lacked knowledge about the parts of computers, and as a consequence had a more difficult time learning a programming language. I assumed, therefore, that the knowledge acquired from this passage would serve as a conceptual framework (Frederikson, 1975; Ausubel, 1978; Mayer, 1979) for learning the second passage which was about programming.

The second passage taught seven commands found in many programming languages. The passage presented six types of information about each command: 1) a brief statement about the function of the command; 2) a general statement (including an analogy) about the format of the command; 3) a technical specification of the format; 4) a general statement about what the command causes the computer to do; 5) a technical list of the operations performed by the command; and 6) an example of a command in the correct format and a list of the operations the example command would perform. Material in types 1, 2 and 4 were considered primary content while material in types 3, 5 and 6 were secondary content.

The second passage used technical terms referring to parts of a computer without defining those terms. It referenced operations performed by the commands without describing those operations. In effect, I designed the passage with the assumption that learners will have studied previously the first passage which defined the terms and clarified the antecedents of the operations. I specifically designed the treatment passage in this manner so as to maximize the amount of transfer that would occur. I followed the example set by Royer and Cable (1975; 1976) of using concrete analogies, designed to form a "bridge" to students' existing prior knowledge (Royer, 1979) and thereby give meaning to the technical terms used abstractly in the second passage. Royer and Cable (1975; 1976) observed facilitated transfer of learning across two contiguous passages only when the first passage contained concrete, easily understood information and the second passage contained abstract, hard to understand information.

Dependent Measures

The dependent measures in all three studies consisted of two sets of multiple choice questions. One set consisted of questions testing comprehension of primary ideas (main points) and the other tested comprehension of secondary ideas (details). The number of itmes in each set increased with each study and many of the items were rewritten before being used again. Therefore, the dependent measures across the three experiments were similar but not identical. Furthermore, the two sets were combined into one measure of comprehension in the first study.

Study I

Design

The design of the first study consisted of a single independent variable with two levels. The variable was type of terminology and the two levels were similar terminology and dissimilar terminology. One group received the two treatment passages with identical terminology for shared concepts (e.g., card reader). The other group received the same passages but with different terminology in the first passage (e.g., input tray for card reader). Both groups received the second passage as soon as they had finished reading the first.

The intent of the first study was to measure the effect of type of terminology on transfer of learning across contiguous passages. It was hypothesized the dissimilar terminology would interfere with transfer.

Subjects

Subjects were 21 juniors and seniors from the same high school psychology class. They were randomly assigned to treatment conditions. Subjects had as much time as needed although all finished within 40 minutes.

Results

The posttest scores were much lower than expected. The test was difficult and subjects reported that they had not anticipated having so many questions about "details." Table 1 summarizes the results of the study.

Treatment Condition	Number of Subjects	Mean*	Standard Deviation
Similar Term.	12	7.83	2.40
Dissimilar Term.	9	8.10	3.30

The difference between means is not significant (T = 0.40, alpha = 0.05).

*Total number of items was 30.

Study I: Means and standard deviation

Table 1

The results must be interpreted cautiously because of the potential flooring effect of the test. However, the insignificant differences in the means between the two treatment groups suggests that dissimilar terminology was not debilitating when passages occur close in time. The potential impediment of dissimilar terminology on bottom-up processing may have been compensated for by the facilitating effects of conceptual similarity on top-down processing and/or by the additional efforts of students with dissimilar terminology to cope with their unfavorable condition.

The results also indicate two areas in which the treatment materials and dependent measure needed improvement before used in the second study of subsequent research: 1) The test items needed to be improved (made easier); and 2) The students needed to be alerted to read for details.

Study II

Design

The second study included two out of four treatment conditions corresponding to a 2x2 factorial design. The independent variables in the full design were 1) type of terminology across two passages (similar and dissimilar) and 2) temporal relationship between two passages (contiguous and noncontiguous).

Similarity of Terminology	Temporal Relationship: Contiguous	Temporal Relationship: Noncontiguous
Similar	Study 1 Study 2	
Dissimilar	Study 1	Study 2

Figure 1.

As can be seen in Figure one, my first study compared a contiguous-similar group with a contiguous-dissimilar group. The second study compared a contiguous-similar group with a noncontiguous-dissimilar group. This study also included a control condition which included only a second passage and the dependent measure.

Subsects

Subjects were 65 high school seniors from three English composition classes. Their participation in the study was an assigned classroom activity. Students assigned to the similar-contigucus condition received the two passages containing similar terminology for all concepts included in both passages and they read one passage immediately after the other. Student assigned to the noncontiguous-

dissimilar condition received the same two passages except that the terms in the first passage for concepts also taught in the second passage were changed and that the students did not receive the second passage until six days later.

Results

Table 1 contains the means and standard deviations of the three condition groups on the dependent measure. Planned comparisons using the T statistic revealed several significant differences between means as indicated in Table 2.

Treatment Condition	n	Primary Mean	Primary SD	Secondary Mean	Secondary SD
1) Contiguous-Similar	18	6.5*	3.31	5.6+	2.61
2) Noncontiguous-Disimilar	16	4.30	1.42	3.9	1.54
3) control	11	4.5	1.92	5.6+	1.69
Total number of items		14		12	

* Different from groups 2 and 3 ($p < .05$).
+ Different from group 2 ($p < .05$).

Study II: Means and Standard Deviations.

Table 2.

On the total test, students in the contiguous-similar group scored significantly better than students in both the noncontiguous-dissimilar treatment and control conditions ($t(32)=5.24$, $t(27)=2.35$, respectively). An interaction occurred between type of test and treatment condition. On the primary test, students in the contiguous-similar condition performed significantly better than the other two

groups ($t(32)=3.25$, $t(27)=2.51$, respectively), which groups did not differ from each other ($t(24)=0.32$). On the secondary subpart, the contiguous-similar group and control group did not differ from each other and both groups scored significantly better than students in the noncontiguous-dissimilar group ($t(32)=3.46$, $t(27)=3.40$, respectively).

The differences between means from the contiguous-similar condition and the noncontiguous-dissimilar group suggest that dissimilar terminology combined with a lack of temporal contiguity impedes transfer of learning of both primary and secondary content. As found in the first study, dissimilar terminology might not have the same negative effect with contiguous passages.

The differences between means on the secondary test of the noncontiguous-dissimilar and control groups suggests that the unfavorable condition of dissimilar terminology in noncontiguous passages may actually interfere with certain kinds of learning.

The lack of differences between the means on the secondary test of the contiguous-similar and control conditions suggests that students without access to a conceptual framework (i.e., the knowledge structure acquired from reading the first passage and retained in working memory) may resort to rote learning (Mayer and Bromage, 1980; Mayer, 1977). This conclusion seems justified because secondary, factual information tends to be more easily learned by rote learning than primary, abstract information (Ausubel, 1978).

Study III

Design

The design of the third study consisted of two variables with two levels. In addition to type of terminology (similar and dissimilar), there was position of a review of the first passage (before or after the second passage).

The review of the first passage consisted of one or two sentences about each part of the simplified computer. These sentences made reference to the analogies and main ideas; but did not restate any details. The review also contained the diagram used in the first passage representing the simplified computer.

In addition to the four treatment groups formed by the 2x2 design, I included 2 control groups. One control group received contiguous passages with similar terminology and the review before the second passage (best conditions for transfer). The other control group received only the second passage (worst conditions for transfer).

The intent of this study was to test six hypotheses:

H1: Students reading noncontiguous passages with similar terminology will experience more transfer than students reading the same passages with dissimilar terminology.

H2: The effects of similar or dissimilar terminology will be equal for transfer on primary and secondary ideas.

H3: Students reading a review of primary content from a first passage immediately before a noncontiguous second passage will experience more transfer than students reading the same review after the second passage.

H4: The effects on transfer due to when students read a review of a first passage will be greater on primary ideas than on secondary ideas.

H5: Students reading noncontiguous passages with both similar terminology and a review will experience greater transfer than students reading passage with only one of the two conditions

H6: Students reading noncontiguous passages with a review but without similar terminology will experience more transfer than students without a review.

Results

The results failed to support the hypotheses because (1) there were no significant main effects, (2) there was a significant interaction among treatment groups, and (3) the differences between the best case and worst case control groups for comprehension of both primary and secondary ideas were small and not significant. Table 3 reports the means and standard deviations and Table 4 summarizes the analyses of variance among the four treatment conditions.

	Primary Ideas		Secondary Ideas	
	Review before	Review after	Review before	Review after
Similar terminology	9.95 2.43 (20)	7.41 2.55 (19)	8.25 2.78 (20)	6.74 2.49 (19)
Dissimilar terminology	8.95 8.95 (21)	10.74 3.53 (19)	8.14 3.65 (21)	10.00 4.16 (19)
Contiguous passages control		10.91 2.69 (22)		8.73 2.87 (22)
Second-only control		9.52 2.96 (21)		8.95 3.24 (21)

Study III. Means and Standards Deviations

Table 3.

		Primary Ideas		Secondary Ideas	
Source of Variance	df	Sums of Squares	F	Sums of Squares	F
Main Effect	2	24.07	1.46	45.88	1.96
Terminology	1	21.87	2.04	45.29	3.86
Review	1	2.03	.25	.73	.06
Interaction	1	89.48	10.82*	55.99	4.77*
Explained	3	113.55	4.58	1.1.87	2.89
Residual	75	620.32		880.01	
Total	78	733.87		981.87	

*Significant at $p < .05$.

Study III. Analysis of Variance

Table 4.

Overall, students performed much lower than expected on the dependent measure. This unanticipated poor comprehension may be attributed to the difficulty of the reading materials and the ability of the subjects. Because the study was focused on transfer in the context of "technical material," I intentionally made the materials dense with both primary and secondary content. This density of unfamiliar, technical concepts possibly overwhelmed the learners and caused them to lose interest in what they read. I should note, however, that the passages are at an th grade reading level according to the Flesch Kincaid procedure. The subjects were 8 to 20 months younger than subjects used in the second study. While age alone is not a significant factor, ability to read, reason, and learn may be different between the two age groups.

The meaning of the significant terminology by review interaction becomes difficult to explain in light of the comprehension scores of the two control groups. According to the theory outlined earlier, the contiguous control group should have experienced maximum transfer while the second-only control group should not have experienced any transfer. Because the control groups did not differ from each other, I cannot say that the differences among the treatment groups was due to transfer. Clearly, other learning conditions were in operation--some of which might have been influenced by treatment manipulations. For example, the performance of the contiguous control group may be attributable to transfer while the performance of the second-only control group may be attributable instead to rote learning procedures (Ausubel, 1978). Similarly, the treatment groups may have been differentially influenced by transfer and/or rote learning procedures. The similar-before group probably experienced more transfer than the other treatment conditions while the dissimilar-after group probably utilized more rote learning procedures. In the section that follows, I further discuss these tentative conclusions and provide a theoretical basis for them.

General Discussion

I had theorized in earlier that familiarity of technical terminology and a single organizing structure (i.e., existing schemata at both the word and concept levels) were prerequisite for comprehension and transfer. In retrospect, I believe I made a couple of erroneous assumptions: I assumed that because the passage had familiar words (e.g., card and reader) being used in a very technical manner (i.e., card reader) that the terms would not invoke top-down or bottom-up processing. Furthermore, I assumed that because the passages integrated the terms into a novel conceptual structure (i.e., internal

makeup of the computer) that unless that structure was present during reading, the process of comprehending those terms and deriving meaning from the text would break down. While Study II supported these assumptions, Study III provided conflicting evidence.

Rummelhart and Norman (1978) provide a theoretical explanation of the outcomes in Study III. They suggest that when adequate schemata cannot be found to account for incoming data via top-down or bottom-up processing, then the passage "can be understood only in terms of a set of disconnected subsituations (facts)--each interpreted in terms of a separate schema." In other words, many students probably comprehended individual terms or concepts in isolation of each other rather than integrating them within one meaningful structure. According to Ausubel (1978) and others (Mayer, 1979; Mayer & Bromage, 1980), learners without a meaningful structure can, in the short term, evidence as much learning (by rote procedures) as can learners with meaningful structures.

Furthermore, evidence from the second and third studies suggests that weak organizing schemata can actually impede positive transfer and rote learning. If learners are led to believe that a comprehensive, unifying structure is available to better learn and integrate new and difficult ideas, the learners are likely to forgo retrieving a series of disjointed structures. Rather, they will make the new structure do the best it can. However, if that structure is not well developed, (does not contain solid hooks in the right places) then a decrement in leaning over the rote learning procedure is possible.

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